Notice of Allowability	Application No.	Applicant(s)	
	10/814,711	CHANG ET AL.	
	Examiner	Art Unit	
	Hung H. Lam	2622	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *the Telephone Interview on 09/07/07*.

2. ☒ The allowed claim(s) is/are *1, 3-4, 6-10 and 12-20 (Claims are renumbered as 1-17, respectively)*.

3. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
      1. ☐ Certified copies of the priority documents have been received.
      2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
      3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☒ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☒ Information Disclosure Statements (PTO-1449 or PTO/SB/08), Paper No./Mail Date _____
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application (PTO-152)
6. ☒ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☒ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

DETAILED ACTION

Examiner's Amendment

1. An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

2. Authorization for this examiner's amendment was given in a telephone interview with John P. Cornely on 09/07/07.

3. The application has been amended as follows:

Claims 2, 5 and 11 have been canceled and incorporated into independent claims 1 and 10, respectively.

Claim 1 (Currently amended). A method for estimating camera motion parameters, the method comprising:

obtaining an observation point set including a plurality of observed point vectors;

computing a plurality of motion output vectors by performing a recursive least squares (RLS) process based on a plurality of motion parameter vectors; and,

comparing the plurality of motion output vectors to the plurality of observed point vectors.

wherein the computing a plurality of motion output vectors and the comparing the plurality of motion output vectors to the plurality of observed point vectors comprise:

initializing a first covariance matrix to a positive value; setting a first motion parameter estimate vector to an initial value;

determining each of the plurality of motion parameter vectors, the determining comprising: computing a current covariance matrix;

computing a current motion parameter estimate vector based on the current covariance matrix; computing a current motion output vector and a current state variable matrix based on the current covariance matrix; and,

comparing the current motion output vector to the observation point set; and, repeating the determining a predetermined number of times.

wherein: the computing a current covariance matrix comprises computing $P_t = P_{t-1} + P_{t-1}\phi_t\left[I + \phi_t' P_{t-1}\phi_t\right]^{-1}\phi_{t-1}' P_{t-2}$, P_t being the current covariance matrix, P_{t-1} being the prior current covariance matrix, P_{t-2} being the second prior current covariance matrix, ϕ_t being the current state variable matrix, ϕ_{t-1} being the prior current state variable matrix, and I being the identity matrix; and,

the computing a current motion parameter estimate vector comprises computing $\hat{\theta}_t = \hat{\theta}_{t-1} + \left[P_{t-1}\phi_t\left[I + \phi_t' P_{t-1}\phi_t\right]^{-1}\right]\left[y_t - \phi_t\hat{\theta}_{t-1}\right]$, $\hat{\theta}_t$ being the current motion parameter estimate, $\hat{\theta}_{t-1}$ being the prior current motion parameter estimate, and y_t being the current motion output vector.

Claim 2 has been canceled.

Claim 3 (Currently amended). The method as set forth in claim ~~2~~ 1 , wherein the obtaining includes obtaining m number of points and n number of observations for each of the m number of points; and the repeating includes repeating the determining n times.

Claim 5 has been canceled.

Claim 6 (Currently amended). The method as set forth in claim ~~2~~ 1 , wherein: the determining further includes computing a random noise vector of the form $e = [e_1 \quad e_2 \quad e_3]$;

the computing a current motion parameter estimate vector includes computing the current motion parameter estimate vector which includes a plurality of noise vector transformation parameters; and,

the computing a current motion output vector includes computing the current motion output vector which includes a transformation of the random noise vector.

Claim 10 (Currently amended). A method for determining a filter to correct for camera motion errors, the method comprising:

determining a plurality of desired motion point vectors;

computing a plurality of estimated motion point vectors by means of an RLS algorithm; and,

computing the filter based on a difference between the plurality of estimated motion point vectors and the plurality of desired motion point vectors.

wherein:

the determining a plurality of desired motion point vectors comprises determining the desired motion as described by $X_{t+1} = R_d X_t + T_d$, where X_t is the motion output matrix at time t, X_{t+1} is the motion output matrix at time $t+1$, R_d is the desired rotation matrix, and T_d is the desired translation vector;

the computing a plurality of estimated motion point vectors comprises computing the estimated motion as described by $X_{t+1} = R_e X_t + T_e + c_e e$, where R_e is the estimated rotation matrix, T_e is the estimated translation vector, c_e is a noise transformation matrix, and e is a random noise vector; and,

the computing the filter comprises:

computing a filter rotation matrix according to $R_f = R_e - R_d$; and,

computing a filter translation vector according to $T_f = T_e - T_d$.

Claim 11 has been canceled.

Claim 12 (Currently amended). The method as set forth in claim ~~11~~ 10, further comprising computing a corrected output according to $X_{t+1} = R_f X_t + T_f + c_e e$.

Allowable Subject Matter

4. Claims 1, 3-4, 6-9, 10 and 12-20 are allowed.

5. The following is an examiner's statement of reasons for allowance:

Regarding claim 1 the prior art of record neither anticipates nor renders obvious, a method for estimating camera motion parameters, the method comprising:

obtaining an observation point set including a plurality of observed point vectors;

computing a plurality of motion output vectors by performing a recursive least squares (RLS) process based on a plurality of motion parameter vectors; and,

comparing the plurality of motion output vectors to the plurality of observed point vectors.

wherein the computing a plurality of motion output vectors and the comparing the plurality of motion output vectors to the plurality of observed point vectors comprise:

initializing a first covariance matrix to a positive value; setting a first motion parameter estimate vector to an initial value;

determining each of the plurality of motion parameter vectors, the determining comprising: computing a current covariance matrix;

computing a current motion parameter estimate vector based on the current covariance matrix; computing a current motion output vector and a current state variable matrix based on the current covariance matrix; and,

comparing the current motion output vector to the observation point set; and,

repeating the determining a predetermined number of times.

wherein: the computing a current covariance matrix comprises computing $P_t = P_{t-1} + P_{t-1}\phi_t\left[I + \phi_t' P_{t-1}\phi_t\right]^{-1}\phi_{t-1}' P_{t-2}$, P_t being the current covariance matrix, P_{t-1} being the prior current covariance matrix, P_{t-2} being the second prior current covariance matrix, ϕ_t being the current state variable matrix, ϕ_{t-1} being the prior current state variable matrix, and I being the identity matrix; and,

the computing a current motion parameter estimate vector comprises computing $\hat{\theta}_t = \hat{\theta}_{t-1} + \left[P_{t-1}\phi_t\left[I + \phi_t' P_{t-1}\phi_t\right]^{-1}\right]\left[y_t - \phi_t\hat{\theta}_{t-1}\right]$, $\hat{\theta}_t$ being the current motion parameter estimate, $\hat{\theta}_{t-1}$ being the prior current motion parameter estimate, and y_t being the current motion output vector.

Regarding claim 10 the prior art of record neither anticipates nor renders obvious, a method for determining a filter to correct for camera motion errors, the method comprising:

determining a plurality of desired motion point vectors;

computing a plurality of estimated motion point vectors by means of an RLS algorithm; and,

computing the filter based on a difference between the plurality of estimated motion point vectors and the plurality of desired motion point vectors.

wherein:

the determining a plurality of desired motion point vectors comprises determining the desired motion as described by $X_{t+1} = R_d X_t + T_d$, where X_t is the motion output matrix at time t, X_{t+1} is the motion output matrix at time $t+1$, R_d is the desired rotation matrix, and T_d is the desired translation vector;

the computing a plurality of estimated motion point vectors comprises computing the estimated motion as described by $X_{t+1} = R_e X_t + T_e + c_e e$, where R_e is the estimated rotation matrix, T_e is the estimated translation vector, c_e is a noise transformation matrix, and e is a random noise vector; and,

the computing the filter comprises:

computing a filter rotation matrix according to $R_f = R_e - R_d$; and,

computing a filter translation vector according to $T_f = T_e - T_d$.

Regarding claim 17 the prior art of record neither anticipates nor renders obvious, a system for estimating and filtering camera motion parameters, the system comprising:

a movable digital camera for generating a plurality of 2-dimensional images of a scene or object;

a control means for translating and rotating the camera along a predetermined trajectory;

a computer system for receiving and processing the plurality of 2-dimensional images, the computer system including: a user interface for receiving instructions from a user and for providing output to a user;

an image input means for receiving the plurality of 2-dimensional images from the camera; a storage means for storing programs and the plurality of images;

a program to determine a desired motion, the desired motion described by

a program to determine a desired motion, the desired motion described by $X_{t+1} = R_d X_t + T_d$, where X_t is the motion output matrix at time t, X_{t+1} is the motion output matrix at time $t+1$, R_d is the desired rotation matrix, and T_d is the desired translation vector; and,

a program to compute an estimated motion by means of an RLS program, the estimated motion described by $X_{t+1} = R_e X_t + T_e + c_e e$, where R_e is the estimated rotation matrix, T_e is the estimated translation vector, c_e is a noise transformation matrix, and e is a random noise vector.

Regarding claims 3-9, 12-16 and 18-20, the claims are allowed as being dependent of claims 1, 10 and 17, respectively.

6. Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance." Any inquiry concerning this communication or earlier communications from the examiner should be directed to Hung H. Lam whose telephone number is 571-272-7367. The examiner can normally be reached on Monday - Friday 8AM - 5PM.

Conclusion

7. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

a) Carmeli (US-5,699,440) discloses an apparatus for calibrating camera.

b) Zang (US-7,250,965) discloses a system for calibrating a camera with one-dimensional object.

c) Scheele (US-6,377,298) discloses a device for calibration of CCD cameras.

d) Robinson (US-6,016,161) discloses a system for automatically calibrating machine vision system.

8. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, LIN YE can be reached on 571-272-7372. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you

have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

HL
09/09/07

TUAN HO
PRIMARY EXAMINER